CHAPTER ONE

Purpose of and Need for a Subtidal Habitat Goals Report

THIS SAN FRANCISCO BAY SUBTIDAL HABITAT GOALS REPORT is designed to give resource managers, regulatory agencies, environmental groups, researchers, industry, and anyone interested in this important bay habitat the basic information they need to plan conservation, restoration, research, and management activities related to subtidal habitat in the San Francisco estuary.

As defined here, subtidal habitat includes all of the submerged area beneath the bay water's surface: mud, shell, sand, rocks, artificial structures, shellfish beds, submerged aquatic vegetation, macroalgal beds, and the water column above the bay bottom.

The Need for a Subtidal Goals Project

Pacific herring (shown here in kelp) use eelgrass beds as a spawning substrate in San Francisco Bay.

In the past several decades, with the goal of improving the San Francisco Bay ecosystem, resource agencies and environmental groups have made enormous efforts—many are completed or underway, and others still in the planning stages—to restore the wetlands at the bay's edges, the streams and riparian areas throughout its watersheds, and, more recently, the remaining open spaces of its uplands. Much of this effort has focused on restoring tidal wetlands. However, most wetland restoration projects to date have not been designed with subtidal resources in mind, despite the fact that subtidal areas are intrinsically connected to mudflats, wetlands, creeks, and uplands. Until very recently the area beneath the bay's surface was "out of sight, out of mind"—unless obstacles needed to be removed or channels dredged to ensure safe passage for ships, or when sand, shell, or mud were needed for construction and other human activities.

Government agencies with authority for managing the estuary lack sufficient information about subtidal habitats in the bay to inform management decisions. Although a tremendous amount of scientific information is available from research and monitoring in the bay, little of it is useful in making decisions about specific proposals for development or restoration as they relate to subtidal habitat. Part of the reason for this shortfall is that subtidal habitats

are usually invisible in the bay's turbid waters, and most sampling methods cannot provide detailed information about the location and condition of the various habitats. Furthermore, relatively little research has been conducted that would provide key support for the Subtidal Goals Project on the extent and value of the ecosystem services provided by each habitat, and the threats those habitats face—information that is needed to protect and restore these habitats. Equally important is the need to learn more about the functions of these habitats, how they respond to environmental change, and how to protect and enhance them.

A number of ongoing planning efforts successfully address various aspects of natural resource conservation in the San Francisco Bay region (see box for a list of other such planning efforts). Many of these planning efforts address components of subtidal habitats from different planning or regulatory perspectives, depending on the entities involved in the efforts and their individual mandates and authorities. The Subtidal Goals Project is the first effort to focus on all subtidal habitats within San Francisco Bay. Implementation of the goals presented here is intended to build upon and complement existing efforts. In particular, the perspective of the Subtidal Goals Project is physical habitat rather than protection or enhancement of species, which is the purview of agencies implementing federal or state Endangered Species Acts or regulating collection and harvest.

OTHER PLANNING EFFORTS RELATED TO SUBTIDAL HABITAT

Bay Delta Conservation Plan (http://baydeltaconservationplan.com/default.aspx)

Baylands Ecosystem Habitat Goals Project (http://www.sfei.org/)

Comprehensive Conservation and Management Plan (www.sfestuary.org)

Humboldt Bay Subtidal Goals Project (http://groups.ucanr.org/HumboldtHabitatGoals/)

North Richmond Shoreline: A Community Vision (http://www.restorationdesigngroup.com/docs/NorthRichmondShorelineVision.pdf)

Regional Boards Basin Plan (http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml#2004basinplan)

Regional Monitoring Plan (http://www.sfei.org/rmp/)

Richardson Bay Plan (http://www.tiburonaudubon.org/conserve_planning.html)

Richardson Bay Special Area Plan (http://www.bcdc.ca.gov/laws_plans/plans/plans.shtml)

San Francisco Bay Plan (http://www.bcdc.ca.gov/laws_plans/plans/sfbay_plan.shtml)

Uplands Habitat Goals Project (http://www.uplandhabitatgoals.org/)

Long Term Management for Disposal of Dredged Material in San Francisco Bay (http://www.bcdc.ca.gov/dredging/ltms/ltms_program.shtml)

Dredged Materials Management Office (http://www.spn.usace.army.mil/conops/dmmo.htm)

Above and below the surface of the bay (near the Tiburon Peninsula).

Vision Statement

The vision of the Subtidal Goals Project is to achieve, over the next 50 years, a net improvement of the San Francisco Bay's subtidal ecosystem through science-based protection and restoration of habitats. To achieve this improvement, the Subtidal Goals Project proposes:

- Increasing the quantity of desired but currently limited habitats;
- Emphasizing support of native species;
- Increasing our understanding of the physical and biological processes that affect subtidal habitats and the use of these habitats by species.

Neither a policy nor regulatory document, this report offers guidance on opportunities for subtidal restoration and protection. Implementation will occur through a number of avenues: local governments may incorporate these recommendations into their planning processes and documents, non-profits may use them when seeking funding for restoration or management projects, and researchers may wish to refer to the report when setting priorities. Regulatory agencies may use this report to evaluate, revise, or implement their policies.

New policies or modifications to existing policies proposed on the basis of this report will require a separate process in which each agency will analyze recommended policies in the context of their existing authorities and public input process.

San Francisco State University researchers monitor the eelgrass bed at Point Orient on the Richmond shoreline.

Planning Framework and Approach

The Subtidal Goals Project is a collaboration among the San Francisco Bay Conservation and Development Commission (BCDC), California Ocean Protection Council (OPC)/California State Coastal Conservancy (SCC), National Oceanic and Atmospheric Administration (NOAA) and the San Francisco Estuary Partnership (SFEP). Lead staff from those agencies worked with the broader scientific community, managers, restoration practitioners, and stakeholders over several years to develop the goals set forth in this document. See Appendix 1-1 for details on project methods and participant roles.

The Goals Project was inspired by the 1999 Baylands Ecosystem Habitat Goals report (Figure 1-1), which set a bold vision for restoring 100,000 acres of wetlands and related habitats around the bay that have resulted in 13,000 acres of newly restored habitat, with an additional 40,000 acres acquired and in various stages of restoration planning. The Subtidal Goals Project also takes a bay-wide approach in setting science-based goals for maintaining a healthy, productive, and resilient ecosystem. Where possible, these subtidal goals are designed to connect with intertidal habitats and with goals developed by other projects, including goals for baylands and uplands habitats. Unlike in the Baylands Goals effort, however, historical information about subtidal habitat is lacking. Thus the goals set forth in this document do not attempt to restore the bay to historic conditions but are designed to improve the condition of the subtidal ecosystem. The baseline for the project is 2010, and the planning horizon is 50 years.

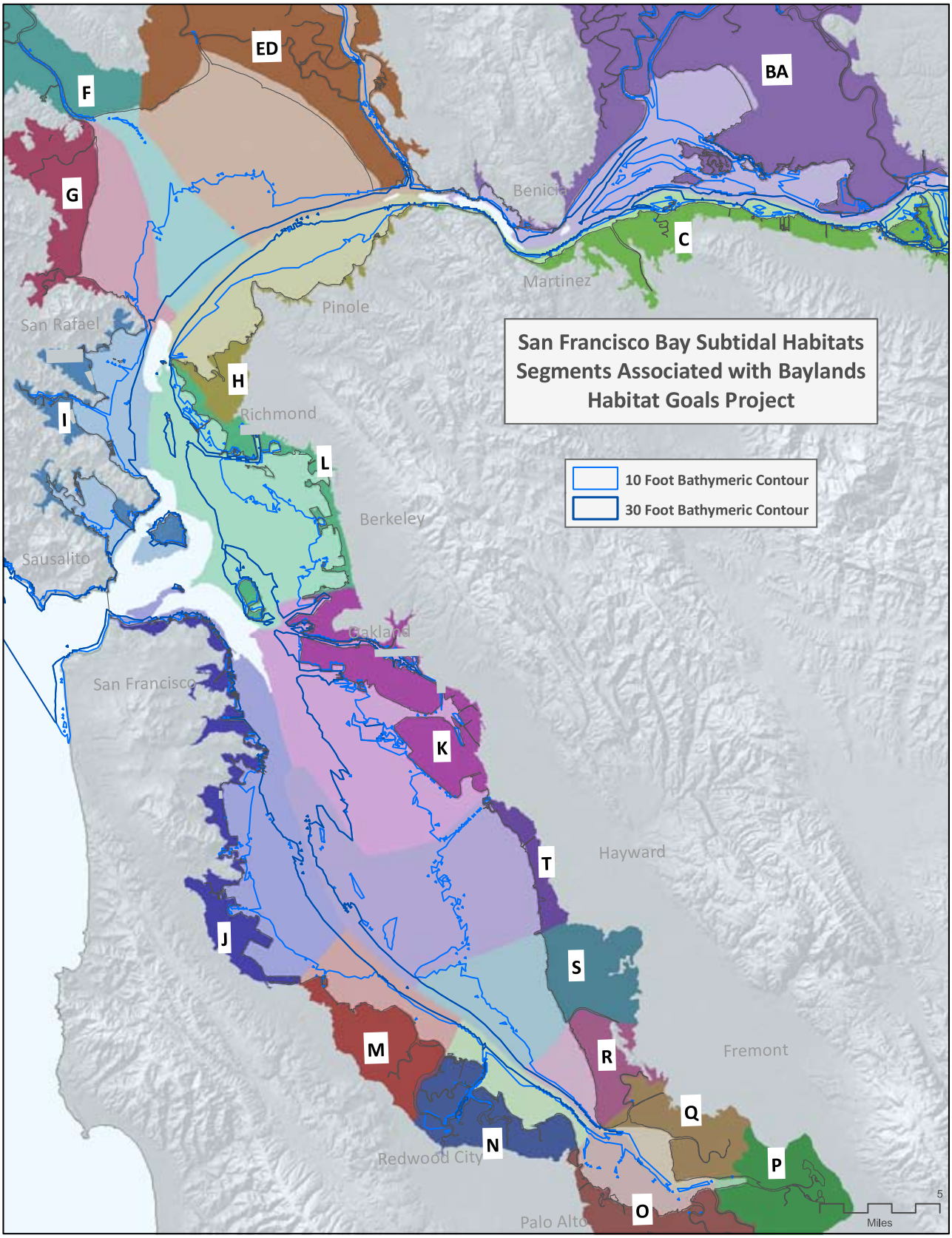

Figure 1-1: Map of Subtidal Habitat Goals aligned with Baylands Ecosytem Habitat Goals segments (represented by letters), extended to three depth categories: 10', or less, 30' or less, and 30' and greater.

FREQUENTLY USED TERMS

Ecosystem: a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit. A well-defined ecosystem has strong interactions among its components and weak interactions across its boundaries.

Habitat: As used by ecologists, "habitat" refers to a combination of physical, chemical, and biological conditions that supports a population of some species. In this document it is used to distinguish among areas of the estuary mainly on the basis of physical configuration, under the assumption that suitable physical conditions will support desirable ecological functions or species.

Intertidal zone: The area that is exposed to the air at low tide and underwater at high tide (for example, the area between tide marks). This area can include many different types of habitats, including rocky areas, sandy beaches, or wetlands (e.g., vast mudflats).

Restoration: Restoration is defined as actions taken in a converted or degraded natural habitat that result in the reestablishment of ecological processes, functions, and biotic/abiotic linkages and lead to a persistent, resilient system integrated within its ecological landscape. For the Subtidal Goals Project, the term "restoration" is also meant to include actions such as creating, enhancing, remediating, and rehabilitating.

Subtidal habitat: all of the submerged area in the estuary.

For more definitions, please see the Glossary, Appendix 1-4.

How the lead agencies will use this report

NOAA, BCDC, SFEP, SCC, and OPC each have different authorities, mandates, and policies regarding conservation and management of subtidal habitats. As such, each agency may choose to use this document in different ways.

- While this document does not supersede or change NOAA authorities or mandates, NOAA staff may reference information in this document when implementing consultations pursuant to the Endangered Species Act and the Essential Fish Habitat provisions of the Magnuson-Steven Fishery Conservation and Management Act.
- NOAA may reference this document when evaluating research priorities both for NOAA Science Centers and other scientific entities.
- The NOAA Restoration Center may use this document to help prioritize restoration projects for funding and support.
- San Francisco Bay Conservation and Development Commission staff may use this document as background material when considering future revisions to the San Francisco Bay Plan and may reference this document when evaluating proposed projects under BCDC's existing regulatory authority over development in and around San Francisco Bay.
- The San Francisco Estuary Partnership may reference information in this document when implementing the Comprehensive Conservation and Management Plan for San Francisco Bay, in seeking federal dollars for San Francisco Bay conservation, and in selecting restoration and/or research projects to fund.
- The State Coastal Conservancy may use this document to identify acquisition opportunities, prioritize conservation and strategic planning, and develop restoration projects to support and fund. The Ocean Protection Council may utilize the document in making decisions and prioritizing research areas, especially as they relate to issues of land-sea interface interactions, ecosystem research, and climate change planning.

Background

San Francisco Bay is one of the largest and most important estuaries on the West Coast, both for the habitat it provides for fish and wildlife and for the many benefits and opportunities it offers people. Its natural beauty gives the Bay Area the iconic identity for which it is known throughout the world, while its waters ensure an enviable climate and quality of life for over 7.5 million residents. The bay provides numerous benefits to humans known as "ecosystem services" (see sidebar and Table 1-1). Many residents commute across the bay on ferries, or enjoy it while boating, fishing, swimming, windsurfing, and birding in and around its waters. Visitors from around the country and world are drawn to San Francisco Bay as well: in 2009, the City of San Francisco hosted over 15 million visitors, adding some $8 billion to the Bay

Table 1-1: Subtidal Habitat Ecosystem Services
Through successful implementation of the subtidal goals and vision, the Subtidal Goals Project hopes to sustain and improve upon the ecosystem services and functions provided by subtidal habitat.

	Soft substrate	Rock	Artificial substrate	Shellfish beds	SAV beds (submerged aquatic vegetation beds)	Macro–algal beds	Water column
PROVISIONING SERVICES: products obtained from the ecosystem such as food (e.g. fishing), fiber, fuel or materials (e.g. sand)							
Commercial harvest (i.e., fishing)	•	•		•	•	•	•
Sand and shell mining	•						
Shipping and ports	•						•
Marinas	•						•
REGULATING SERVICES: benefits obtained through ecosystem processes (e.g., maintenance of air and water quality, erosion control, climate regulation, storm protection)							
Clean water	•			•	•	•	•
Shoreline protection		•	•	•	•	•	
CULTURAL SERVICES: nonmaterial benefits from spiritual enrichment, reflection, recreation, and aesthetic experiences (e.g., cultural diversity, educational values, inspiration, sense of place, recreation and ecotourism)							
Diversity of ecosystem	•	•	•	•	•	•	•
Inspiration for art, folklore, national symbols, architecture	•	•	•	•	•	•	•
Aesthetics		•	•	•	•	•	•
Sense of place		•	•	•	•	•	•
Recreation—wildlife viewing	•	•	•	•	•	•	•
Recreation—harvest	•	•		•	•	•	•
Recreation—boat use							•
Recreation—shoreline/beach use	•	•	•				•
Ecotourism	•	•	•				•
SUPPORTING SERVICES: indirect services, or those that occur over long periods of time, that are necessary for the production of all other ecosystem services (e.g., production of oxygen through photosynthesis, primary production, nutrient cycling, water cycling)							
Primary production	•				•	•	•
Nutrient cycling	•			•	•	•	•
Biodiversity	•	•	•	•	•	•	•

Above left: Dozens of private and public boats join the Queen Mary II as it enters San Francisco Bay. Above right: Shorebirds forage on intertidal and subtidal mudflats.

Area economy. The bay is also a busy center of commerce: cargo ships and tankers from around the Pacific Rim depend on its ports and infrastructure. Approximately two million tons of sand are mined from subtidal areas each year for use in construction. Historical oyster shell deposits are mined for livestock and chicken feed, soil conditioner, and as a dietary supplement for human consumption.

The bay also supports a variety of "indirect" ecosystem services including nutrient cycling, climate regulation, flood protection, water quality maintenance, and sediment transport. For more information on these uses and benefits of the bay, please refer to Appendix 1-2, the San Francisco Bay Subtidal Economic Evaluation Final Report.

Native Olympia oysters attach themselves to Pacific oyster shells, which are used as a substrate for restoration projects.

In addition to offering these aesthetic, economic, and recreational values, the bay supports a critical food web. Herring and Dungeness crab, among many other species of fish and shellfish, rear in its waters while sturgeon, salmon, and steelhead feed and rest in the bay during their migrations to and from its rivers and streams and the ocean. Its vast open water, sloughs, rivers, streams, and tidelands host millions of migratory birds every year as they move up and down the Pacific Flyway, as well as provide habitat for numerous resident water, shore, and song birds. The bay also provides important habitat for marine mammals, shellfish, and aquatic invertebrates—the smaller, often unseen but important inhabitants of the estuarine ecosystem.

Herring roe spawn on restored native oyster reefs in San Rafael.

Subtidal habitat is a critical piece of this ecosystem. Although this hidden underbelly of the bay is often thought of as a featureless mud bottom, it includes a suite of unique habitats: sand waves more than three meters high; eelgrass and shellfish beds that act as ecosystem engineers and provide substrate for organisms to attach their eggs to and food resources for species such as herring and salmon; rocky outcrops covered in seaweeds and invertebrates; and mixed sediments in shoals and channel banks that are used by a variety of species. Many shellfish, macro- and micro-invertebrates, fish, marine mammals, diving ducks, and other wildlife feed, rest, hide, and reproduce in these areas. Large populations of shorebirds feed on the estuary's subtidal and intertidal mudflats.

The focus of this report is on preserving and restoring the bay's subtidal resources for their ecosystem functions and habitat values and for their ecosystem services to humans (see Table 1-1). As such, while all of the ecosystem services provided by San Francisco Bay subtidal habitats are important, this report identifies a subset of ecosystem services that are not directly extractive or destructive of those habitats. The vision statement and goals presented herein were developed to support, maintain, and improve upon this subset of ecosystem services for continued future benefit to Bay Area residents.

Physical setting

The distribution of habitats within the estuary results from a combination of geology, tidal and freshwater flows, currents, wind, biological activity, and human activity. The geologic setting of the estuary includes two features that are key to its shape and characteristics. First, this tectonically shaped estuary bisects the Coast Range, resulting in areas where river flows during lower stands of sea level carved out narrow, deep channels (Golden Gate, Raccoon and Carquinez Straits) interspersed with broad regions (e.g., South Bay, San Pablo Bay) where the estuary spreads into extensive shallow shoals. Second, the estuary's watershed includes 40% of the area of California and some of the state's highest terrain in the Sierra Nevada, providing the fresh water to establish a salinity gradient, and sediment that allows shoals to form (and keeps the bay turbid). The sediment pulse resulting from hydraulic mining in the late 19th century caused over a meter of shoaling in some areas of the estuary, and has yet to fully dissipate; when it does, the ensuing sediment shortage due to trapping behind dams in the Sierra foothills may cause erosion of valued habitats.

The estuary is comprised of the Sacramento-San Joaquin Delta, Suisun Marsh, and four basins linked through passes or over shoals (Figure 1-2). All of the basins have shallow areas with mud to sand bottom, and deeper channels with mainly sand bottom. All have mean depths of 5m or less, except the Central Bay, which has an average depth of 12m. Shorelines vary from armored revetments to beaches to marsh, and all basins adjoin mainly urban and industrial areas. Tidal currents are strong in many parts of the estuary, particularly the narrower sections where the estuary penetrates the Coast Range at the Golden Gate and Carquinez Strait. Wind is also strong, especially during summer and east of gaps in the Coast Range. Wind-driven waves re-suspend sediments and increase turbidity locally. Salinity varies from oceanic values near the Golden Gate to freshwater values in the northern estuary, typically in Suisun Bay or the western delta depending on freshwater flow from the delta.

Suisun Bay is the easternmost of the estuary's large basins. In the north are Grizzly and Honker Bays, which link to Suisun Marsh, a network of channels and sloughs adjacent to islands that are mostly managed as freshwater marshes for waterfowl, with a small area of remnant natural brackish marshes. A deep

Figure 1-2: Map of sub-basins.

New eelgrass shoots from a transplant restoration project along the San Rafael shoreline.

channel near the southern shore of Suisun Bay links the delta, to the east, to Carquinez Strait to the west. A shallower channel to the north connects to the main channel near Benicia and Pittsburg. Salinity is typically fresh in wet winters and brackish in dry summers and is usually vertically unstratified.

San Pablo Bay is linked to Suisun Bay by Carquinez Strait, a narrow, sinuous channel with maximum depth of about 40m. San Pablo Bay has a single deep water channel and a broad shoal extending to the northwest. This is the only basin with substantial agriculture along the shore. Several salt ponds have been restored or are in planning for restoration to tidal wetlands or enhanced managed ponds along the northern shore. Brackish tidal marshes adjoin San Pablo Bay, including the San Pablo Bay National Wildlife Refuge and the National Estuarine Research Reserve site at China Camp. Salinity can be fresh during extreme floods but is typically near seawater salinity values in dry summers, and is often stratified, especially during high-flow periods. This is an important area for migratory shorebirds and ducks.

The Central Bay is the deepest basin, has the largest extent of rocky substrate, including areas around islands and seamounts, and is the most influenced by the coastal ocean. Much of the bottom is either rocky or sandy, with large sand waves illustrating the strength of tidal currents in this region. The deepest point is over 100m deep near the Golden Gate Bridge. The water here is the saltiest in the bay (on average), with strong stratification present during high-flow periods, and is the clearest of all the basins. This region is a crossroads for shipping to and from the numerous bay ports, and the most popular for water-based recreation such as sailing, because of the dependable winds, varied conditions, and spectacular views. Central Bay has the most marine species and probably the highest species diversity in the estuary.

Above: Sand dredger in San Francisco Bay. Right: Maintenance dredging at the Port of Richmond.

The South Bay is an isolated arm of the estuary. Its shoreline is mostly urban and industrial, but in the far south numerous salt ponds adjoin the bay, some of them slated for conversion to tidal wetlands or enhanced managed ponds. The South Bay Salt Ponds Project is the largest tidal restoration project west of the Mississippi. During high-flow periods, salinity in the South Bay is reduced by brackish water from the Central Bay and fresh water from streams. During the dry season, salinity in the South Bay becomes somewhat elevated because of evaporation, and its only freshwater supply comes from wastewater treatment plants. The South Bay is also an important area for shorebirds and water birds.

A changed estuary

In addition to historical impacts from gold-mining, humans have altered the shape and size of the bay, converted shorelines from marsh to seawall, diverted water from upstream rivers, preventing it from flowing into the estuary, added innumerable structures to its edges and bottom, removed submerged rocks, and plied the bay with ships, boats, trawls, and dredges.

Activities associated with fishing, marinas, shipping and ports, dredging, sand and shell mining, transportation, recreation, and industry have all had impacts on the bay's subtidal habitat. Subtidal habitat is also threatened by invasions of non-native species (as a result of human actions, most non-intentional), legacy pollutants (such as mercury from gold mining and a variety of chemicals formerly used in industry), and modern-day pollution from "point sources," such as industry and sewage treatment plants, as well as "non-point sources," such as the runoff from our streets and watersheds.

Since the Gold Rush, the bay has lost more than 90% of its historic tidal wetlands. Filling of the shoreline and in the bay has shrunk the bay by almost a third. This has caused a substantial (but unknown) loss of subtidal habitat. This loss and degradation has decreased the value and extent of habitat for many species. The biomass of wetland and subtidal vegetation and shellfish has been

reduced; these resources likely provided copious food resources to humans and animals alike in the past. The intricate matrix of wetland channels, with their three-dimensional surfaces, has been filled in to build salt ponds, urban landfills, airports, ports, and marinas. The resulting loss of habitat complexity probably reduced the abundance of many types of estuarine and marine organisms and the productivity of pelagic and benthic food webs. Yet despite these changes and challenges,[1] estuarine life persists.

Report Scope, Content, and Organization

The geographic scope of the Subtidal Goals Project is San Francisco Bay from Sherman Island west to the southern extent of the bay and seaward to the Golden Gate (Point Bonita to Point Lobos). Although the delta is not included in the project scope, conditions in the delta and their relationship to subtidal habitat in the bay are addressed in the sections on freshwater input and climate change (Chapter 3). For the purposes of this project, "subtidal habitat" includes all submerged areas of the bay.

This report describes six subtidal habitat types with maps showing their known current distributions, and analyzes present-day threats to those habitats. It presents recommendations for addressing those stressors, for advancing scientific research and understanding, and for protecting and restoring subtidal habitat within the constraints and challenges of an urbanized estuary and incomplete knowledge. It also describes some of the pioneering efforts that have taken place to restore subtidal habitat in the bay. Where appropriate, the report includes discussion of certain intertidal habitats that are not addressed by the Baylands Ecosystem Habitat Goals Project: intertidal mudflats, rocky shorelines, sand beaches, and eelgrass and oyster beds.

Chapter 2 describes the considerations used in the planning decisions that were made in setting the goals for subtidal habitat. Chapter 3 describes both the foundational science goals and other goals that apply to all of the habitat types. Descriptions of specific subtidal habitats and the science, protection, and restoration goals for each of them are set forth in Chapters 4 through 9. Chapter 10 focuses on integrating subtidal planning with wetland and shoreline planning, while Chapter 11 presents recommendations for implementation of the goals. A companion document, NOAA's August 2007 *Report on the Subtidal Habitats and Associated Biological Taxa in San Francisco Bay* (http://www.swr.noaa.gov/hcd/HCD_webContent/nocal/SHABTinSFBay.htm), summarizes existing information regarding subtidal habitats and species use in San Francisco Bay.

1. For a more comprehensive description of human impacts on subtidal habitat since the time of European settlement around the bay, see Appendix 1-3.